

Item 17 - Data Collection and Analytical Needs, presented by Norman Abramson.

Before discussing data and analysis needs, we must determine why data and analysis are required. At all costs we must avoid the collection of data just for the sake of accumulating it, and then deciding what it is good for at some later time. All too often we fisheries workers have collected data without having a well defined plan for its utilization.

In general, we may state that data are needed in order to manage the fisheries. However, that answer is too simple to guide the design of data collection and management research programs as we wish to do at this workshop. To help delineate the objectives more clearly, I have chosen to divide management arbitrarily into the following three levels of sophistication.

Level 1. Based upon a general knowledge of the abundance of stocks of interens, be able to detect problems so that concentrated programs can be directed at these areas. This is probably the minimum level of management that most firheries administrators would wish to employ.

Level 2. To control stock size, stock productivity, and catch by means of regulatory activities. This type of management is usually aimed at obtaining the maximum yield in weight from a stock, consistent with conservation of the resource.

Level 3. This highest level of sophistication in management schemes would aim at optimizing the use of the resource in terms of economic or social benefits. The level of harvesting and the distribution of the catch among the fishing units would, in general, not coincide with those determined under Level 2 Management.

It should be pointed out that Level 2 Management has rarely been achieved in proctice and the much more complicated Level 3 schemes remain in the discussion stage. Of course, most of our fisheries are regulated using regulatory devices which would be appropriate to Level 2 or Level 3 management, but the regulations are not generally based upon the information required to attain true management.

When we consider the types of data which are needed and the analytical methods to be employed for attaining a particular management level, it will be necessary to classify each fishery according to its particular characteristic. These fishery characteristics determine, to

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some extent, the types of regulatory mechanisms which can successfully be employed and thus are relevant when designing data collection and analytical plans. The fishery characteristics I refer to are: primarily recreational, primarily commercial, both recreational and commercial, single species fishery, or multi-species fishery. It will be seen that the list of species on the agenda of this Workshop includes representatives which can be assigned to each of these categories.

#### Data or Estimates Needed for Level 1 Management

Level 1 Management of a single species fishery ordinarily can be carried out if relative abundance of the stock is known. Traditionally, relative abundance has been estimated with the use of catch-per-unit-effort statistics. The implicit assumption involved in such use of catch-per-effort is that however the statistic is calculated, it will be proportional to the abundance of the stock. To be meaningful the effort units must be standardized in a way that corrects for changes in efficiency as a function of time and the effects of aggregation of the fishing units on the fish. In addition, unless a constant fraction of the stock is always available to fishery, compensation must be made for changes in availability over time. Many anomalies which appear when observing catch-per-unit-effort statistics are probably due to such uncompensated changes in availability.

For Level 1 management of multi-species fishery, all of the above information will be needed. In addition, an additional effort adjustment will be required for preferred species effects. Without such an adjustment, raw effort statistics will tend to be overestimates relative to those species which are only secondarily sought after.

#### Data or Estimates Needed for Level 2 Management

Level 2 management, aimed at maximizing the sustainable yield, usually will utilize one of two types of yield models-a Surplus Production Model or a Dynamic Pool Model.

Management based upon a Surplus Production or Schaefer-type Model is generally unsuitable for recreational fisheries. Since regulation is carried out by setting a quota on the aggregate amount of catch or effort. There would be great technical as well as public relations problems in conducting this type of regulation on a sport fishery. Because of this, and because of assumptions associated with these models, they are most useful for commercial fisheries which exploit short-lived species. Also, they may offer the most feasible management methods for unageable animals.

Employment of this method on a single-species commercial fishery, requires statistics giving catch in weight, effort standardized for efficiency, and the distribution of fishing effort relative to the exploited population. Since existent fitting methods perform rather poorly at estimating the

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catchability coefficient and the population size, it is highly desirable to have independent estimates of one of these parameters. For example, independent population estimates might be obtained from egg and larval surveys, from a combination of mortality rate estimates and numbers of fish in the landings, or from direct sea survey estimates of biomass. With the surplus production model it is especially important that catch-per-unit-effort can be assumed proportional to the average population size over the time interval utilized.

To use a Surplus Production Model on one species taken by a multi-species fishery requires, in addition to the factors mentioned above, an correct adjustment is difficult to determine.

Management based on a dynamic pool model may involve either the yield-per-recruit form or a model of the full system. The latter would incorporate a density dependent recruit-spawner relationship and possibly density dependent growth and mortality rates. Estimates of the density dependent effects are so elusive that the yield-per-recruit model has generally been used in management. It has been used to promulgate management regulations for several California recreational species.

Estimates of the following population parameters are requisites for using a dynamic pool model in any fishery situation.

A growth in weight function is required. The data needed to develop this function may be obtained from measuring, weighing, and aging the animals. Alternatively, such a function can be developed from data obtained by growth over a time interval, as determined from tagging experiments.

The natural mortality rate is also needed. This is probably the most difficult parameter to estimate and consequently it is missing from most data sets which otherwise could be used to fit the yield-per-recruit model.

If both total and fishing mortality rate estimates are available, natural mortality may be estimated by subtraction. It can also be obtained from series consisting of total mortality estimates and effort statistics which apply to identical time periods. Here it is essential that fishing mortality can be assumed proportional to effort.

If the species being investigated is taken by a fishery regulated under a size limit, natural mortality may be estimated from the decline in abundance of a year class during the pre-size limit ages. It can also be estimated from the decline in abundance of a year class during the closed season from either statistics gathered from the fishery or from research vessel estimates of abundance. The preceding methods require the

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assumption that natural mortality does not change with age, in the first case, and that natural mortality does not exhibit seasonal systematic changes, in the second case.

Rough estimates of the natural mortality rate can be deduced from von Bertalanffy growth curve parameters. Estimates of  $M$  from this source are not sufficiently accurate for analytical purposes.

Another needed component of the dynamic pool model is the fishing mortality rate. Many methods exist for estimating  $F$ , mostly involving the use of tagging experiments.

It can also be estimated from the catch in numbers over a time period and the average total population over the same period. For example, total population might be determined from an egg and larval survey.

$F$  also could be estimated from effort statistics if it is assumed that fishing mortality is proportional to effort and if the relationship between effort and  $F$  has been established. The Murphy Method is useful for obtaining a time series of fishing mortality estimates, but it requires that natural mortality be known and that an independent estimate of  $F$  be available for a single time interval within the series.

In addition to the preceding parameter estimates required for the yield-per-recruit model, a function relating recruitment to spawning stock is needed for a full self generating dynamic pool model. Based upon data and examples that have appeared on the literature, this function is very difficult to determine. The difficulty may stem from the fact that the assumed mathematical models which have been used are not actually descriptive of the relationship, or because the statistics used to fit the model have very high variability. Since the fitting procedure involves a regression, and only one observation is available for each year, a sufficiently large number of data points has rarely, if ever, been available. Data sources for fitting such models include aged data and accompanying effort statistics or Murphy Method estimates of the absolute abundances of a series of year classes. Other more direct methods of estimating year class abundances might also be used.

I should be pointed out that one of the difficulties in using a dynamic pool model for management purposes, particularly the case of setting a size limit based on a yield-per-recruit model, is that each possible optimum size limit accompanies a different fishing mortality. To regulate a sport fishery by means of a fixed size limit, control over the amount of fishing effort would be needed for optimum management. Alternatively, fishing effort could be continuously measured and the size limit adjusted accordingly.

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### Data or Estimates Needed for Level 3 Management

Before data collection can be planned for Level 3 management, administrative decisions must be reached which define the regions over which optimization will be attempted. Such regions for potential optimization could range from the maximum satisfaction of the aggregate of anglers to the maximum economic contribution to a geographic area. For a mixture of sport and commercial fisheries utilizing the same species, more than one region for optimization may be selected and some formula devised for allocating the resource among competing users. Even for pure recreational fishery, economic aspects as well as angler satisfaction are involved.

Level 3 management of single-or multi-species recreational fishery, requires all of the data base needed for Level 2 management. Assuming some type of angler satisfaction optimization were chosen as a criterion, a great deal of data should be collected regarding the constitution of individual angler's bags. These data should include the numbers of fish composing the bags, the sizes of the fish, the species composition, and the catch rate. Since we have virtually no objective information on the factors which give satisfaction to the sport fisherman, some type of psychological or sociological study should be mounted to measure the satisfaction effects of the aforementioned factors. In addition, such things as the relation of satisfaction to the individual's catch relative to bag or size limits should be evaluated. I believe that as we face increasing angling pressure and substantially nonincreasing fish stocks, we will have to investigate the various factors that give people pleasure from recreational fishing.

With regard to measuring economic benefits resulting from sport fishing activities, data are required on expenditures made for fares and admissions, bait and tackle, and other angling related expenses. Other quantities of possible value include the worth of sport caught fish on a market basis, benefits to businesses only indirectly related to angling, and perhaps the replacement value of the fishing experience. The latter refers to what an angler would charge to give up his right to engage in recreational fishing.

Species or species groups of interest primarily to the commercial fishing industry might be managed at Level 3 based on certain economic measures. These might include net income to the fishery aggregate, income to boat owners, income to fishermen, income to processors, and income to processing workers. A fishery's contribution to the regional economy may well also be a measure of interest.

It is possible that even in a commercial fishery some measure of occupational satisfaction will warrant consideration when promulgating management regulations. For example, many commercial fishermen could

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earn a greater income in shoreside occupations but prefer the way of life involved in fishing. In a sense, the fisherman is always gambling that he will make a "big strike" which may also be part of the allure attached to this occupation.

#### Experimental Management

During the preceding discussions of management under the several levels of sophistication, we have assumed, at least in the case of Levels 2 and 3, that analytical mathematical models would be used to describe the fishery and its effects. Data collection would be designed to estimate parameters and thus fit the models to the data. With sufficiently flexible regulatory mechanisms, management could be conducted on an experimental basis by observing the effects of various types of regulations. However, some type of measurement both of the stocks and of social and economic benefits would be required in order to evaluate the results of experimental management efforts. Perhaps, in view of the difficulties which have been encountered in developing and fitting realistic mathematical models to fish populations, this experimental approach might be the most realistic and fruitful method of engaging in fisheries management.

#### Environmental Conditions

Environmental measurements have not been discussed in the foregoing paragraphs. To the extent that availability is a function of the environment, and there appears to be a strong relationship for many of the subject species, the ability to predict environmental conditions in turn availability would be a powerful management tool. Availability is, or can be, a component of all models and management methods; consequently predictions of availability may be incorporated into the management schemes.

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